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Afroz et al.	Environmental Research (2003)	Review of air pollution and health impacts in Malaysia	CO, Pb, SPM, NO_2, O_3 SO_2	Malaysia	Studies related to air pollution conducted in Malaysia have been few. The air pollution comes mainly from land transportation, industrial emissions, and open burning sources. Among them, land transportation contributes the most to air pollution. 82% of total air emissions come from traffic	In the early days of abundant resources and minimal development pressures, little attention was paid to growing environmental concerns in Malaysia. The haze episodes in Southeast Asia in 1983, 1984, 1991, 1994, and 1997 imposed threats to the environmental management of Malaysia and increased awareness of the environment. As a consequence, the government established Malaysian Air Quality Guidelines, the Air Pollution Index, and the Haze Action Plan to improve air quality. Air quality monitoring is part of the initial strategy in the pollution prevention program in Malaysia. Review of air pollution in Malaysia is based on the reports of the air quality monitoring in several large cities in Malaysia, which cover air pollutants such as Carbon monoxide (CO), Sulphur Dioxide (SO2), Nitrogen Dioxide (NO2), Ozone (O3), and Suspended Particulate Matter (SPM). The results of the monitoring indicate that Suspended Particulate Matter (SPM) and Nitrogen Dioxide (NO2) are the predominant pollutants. Other pollutants such as CO, Ox, SO2, and Pb are also observed in several big cities in Malaysia. The air pollution comes mainly from land transportation, industrial emissions, and open burning sources. Among them, land transportation contributes the most to air pollution. This paper reviews the results of the ambient air quality monitoring and studies related to air pollution and health impacts.
Akimoto, et al.	Science (2003)	Global Air Quality and Pollution	All	Global	Particularly in developing countries, continuing industrialization and migration toward urban centers, megacities are becoming more important sources of air pollution. International initiatives to mitigate global air pollution require participation from both developed and developing countries.	The impact of global air pollution on climate and the environment is a new focus in atmospheric science. Intercontinental transport and hemispheric air pollution by ozone jeopardize agricultural and natural ecosystems worldwide and have a strong effect on climate. Aerosols, which are spread globally but have a strong regional imbalance, change global climate through their direct and indirect effects on radiative forcing. In the 1990s, nitrogen oxide emissions from Asia surpassed those from North America and Europe and should continue to exceed them for decades. International initiatives to mitigate global air pollution require participation from both developed and developing countries.
Arku, et al.	Science of the Total Environment (2008)	Characterizing air pollution in two low-income neighborhoods in Accra, Ghana	PM_{10}, $PM_{2.5}$, NO_2, SO_2	Different neighborhoods in Accra, Ghana	The results show that PM10 at sites in these two neighborhoods ranged from 58 to 94 µg/m3 and PM2.5 from 22 to 40 µg/m3. There is evidence for the contributions from biomass and traffic sources, and from geological and marine non-combustion sources to particle pollution	Sub-Saharan Africa has the highest rate of urban population growth in the world, with a large number of urban residents living in low-income "slum" neighborhoods. We conducted a study for an initial assessment of the levels and spatial and/or temporal patterns of multiple pollutants in the ambient air in two low-income neighborhoods in Accra, Ghana. Over a 3-week period we measured (i) 24-hour integrated PM(10) and PM(2.5) mass at four roof-top fixed sites, also used for particle speciation; (ii) continuous PM(10) and PM(2.5) at one fixed site; and (iii) 96-hour integrated concentration of sulfur dioxide (SO(2)) and nitrogen dioxide (NO(2)) at 30 fixed sites. We also conducted seven consecutive days of mobile monitoring of PM(10) and PM(2.5) mass and submicron particle count. PM(10) ranged from 57.9 to 93.6 microg/m(3) at the four sites, with a weighted average of 71.8 microg/m(3) and PM(2.5) from 22.3 to 40.2 microg/m(3), with an average of 27.4 microg/m(3). PM(2.5)/PM(10) ratio at the four fixed sites ranged from 0.33 to 0.43. Elemental carbon (EC) was 10-11% of PM(2.5) mass at all four measurement sites; organic matter (OM) formed slightly less than 50% of PM(2.5) mass. Cl, K, and S had the largest elemental contributions to PM(2.5) mass, and Cl, Si, Ca, Fe, and Al to coarse particles. SO(2) and NO(2) concentrations were almost universally lower than the US-EPA National Ambient Air Quality Standards (NAAQS), with virtually no variation across sites. There is evidence for the contributions from biomass and traffic sources, and from geological and marine non-combustion sources to particle pollution. The implications of the results for future urban air pollution monitoring and measurement in developing countries are discussed.
Baldasano et al.	Science of the Total Environment (2003)	Air quality data from large cities	O_3, PM_{10}, NO_2, SO_2	Global	SO2 maintains a downward tendency throughout the world, with the exception of some Central American and Asian cities. NO2 maintains levels very close to the WHO guideline value throughout the world. However, in certain cities such as Kiev, Beijing and Guangzhou the figures are approximately three times higher than the WHO guideline value. Particulate matter is a major problem in almost all of Asia, exceeding 300 mg/m3 in many cities. Ozone is a problem for rich and poor. In poor countries and those with low average incomes, concentrations of air pollutants remain high and the tendency will be to increase their emission levels as they develop, making the problem worse.	This paper presents an assessment of the air quality for the principal cities in developed and developing countries. Part of the vast and widely dispersed information on air quality that is available at this time on the Internet was compiled, thus making possible a comprehensive evaluation of the tendencies that emerged at the end of the 20th century. Likewise, these values are compared to the air quality thresholds recommended by two international organizations: guideline levels of the World Health Organization (WHO) and limit values of the European Union (EU), in order to determine air quality concentration levels in large cities around the world. The current situation of air quality worldwide indicates that SO2 maintains a downward tendency throughout the world, with the exception of some Central American and Asian cities. NO2 maintains levels very close to the WHO guideline value around the world. For particulate matter, it is a major problem in almost all of Asia, exceeding 300 mg/m3 in many cities. Ozone shows average values that exceed the selected guideline values in all of the analyses demonstrating that it is a global problem. In general, the worldwide trend is to a reduction in the concentrations of pollutants because of the increasingly strong restrictions which local governments and international organizations impose. However, in poor countries and those with low average incomes, concentrations of air pollutants remain high and the trend will be the elevation of their ground levels as they develop, making the problem even worse.

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Cohen et al.	Journal of Toxicology and Environmental Health (2005)	The Global Burden of Disease Due to Outdoor Air Pollution	$PM_{2.5}$, general	Global	Fine particulate air pollution (PM2.5), causes about 3% of mortality from cardiopulmonary disease, about 5% of mortality from cancer of the trachea, bronchus, and lung, and about 1% of mortality from acute respiratory infections in children under 5 yr, worldwide. This amounts to about 0.8 million (1.2%) premature deaths and 6.4 million (0.5%) years of life lost (YLL). This burden occurs predominantly in developing countries; 65% in Asia alone. Only focused on PM, so the effect is likely underestimated. There is a critical need for better information on the health effects of air pollution in developing counties.	As part of the World Health Organization (WHO) Global Burden of Disease Comparative Risk Assessment, the burden of disease attributable to urban ambient air pollution was estimated in terms of deaths and disability-adjusted life years (DALYs). Air pollution is associated with a broad spectrum of acute and chronic health effects, the nature of which may vary with the pollutant constituents. Particulate air pollution is consistently and independently related to the most serious effects, including lung cancer and other cardiopulmonary mortality. The analyses on which this report is based estimate that ambient air pollution, in terms of fine particulate air pollution ($PM_{2.5}$), causes about 3% of mortality from cardiopulmonary disease, about 5% of mortality from cancer of the trachea, bronchus, and lung, and about 1% of mortality from acute respiratory infections in children under 5 yr, worldwide. This amounts to about 0.8 million (1.2%) premature deaths and 6.4 million (0.5%) years of life lost (YLL). This burden occurs predominantly in developing countries; 65% in Asia alone. These estimates consider only the impact of air pollution on mortality (i.e., years of life lost) and not morbidity (i.e., years lived with disability), due to limitations in the epidemiologic database. If air pollution multiplies both incidence and mortality to the same extent (i.e., the same relative risk), then the DALYs for cardiopulmonary disease increase by 20% worldwide.
Dionisio et al.	Environmental Science and Technology (2010)	Air Pollution in Accra Neighborhoods: Spatial, Socioeconomic, and Temporal Patterns	CO, $PM_{2.5}$	Accra, Ghana	PM in these four neighborhoods is substantially higher than the WHO Air Quality Guidelines. The highest pollution in the poorest neighborhood. In the poor neighborhood, higher concentrations were seen in the 'residential' location compared to the 'traffic' location. Concentrations saw peaks during specific times of day (typically mid-day and evening)	This study examined the spatial, socioeconomic status (SES), and temporal patterns of ambient air pollution in Accra, Ghana. Over 22 months, integrated and continuous rooftop particulate matter (PM) monitors were placed at a total of 11 residential or roadside monitoring sites in four neighborhoods of varying SES and biomass fuel use. PM concentrations were highest in late December and January, due to dust blown from the Sahara. Excluding this period, annual PM2.5 ranged from 39 to 53 μg/m3 at roadside sites and 30 to 70 μg/m3 at residential sites; mean annual PM10 ranged from 80 to 108 μg/m3 at roadside sites and 57 to 106 μg/m3 at residential sites. The low-income and densely populated neighborhood of Jamestown/Ushertown had the single highest residential PM concentration. There was less difference across traffic sites. Daily PM increased at all sites at daybreak, followed by a mid-day peak at some sites, and a more spread-out evening peak at all sites. Average carbon monoxide concentrations at different sites and seasons ranged from 7 to 55 ppm, and were generally lower at residential sites than at traffic sites. The results show that PM in these four neighborhoods is substantially higher than the WHO Air Quality Guidelines and in some cases even higher than the WHO Interim Target 1, with the highest pollution in the poorest neighborhood.
Engelbrecht et al.	Environmental Monitoring and Assessment (2001)	PM2.5 and PM10 concentrations from the Qalabotjha low-smoke fuels macro-scale experiment in South Africa	PM_{10}, $PM_{2.5}$	South Africa	Average PM2.5 and PM10 concentrations during the study period were 86 and 97 μg m−3, respectively, at the three Qalabotjha residential sites, and 50 to 60% lower at the Villiers gradient site. Residential coal combustion had a significant impact on air quality in the vicinity of the residential neighborhood. Domestic fuel switching demonstrated potential to improve air quality.	This article presents results from the particulate monitoring campaign conducted at Qalabotjha in South Africa during the winter of 1997. Combustion of D-grade domestic coal and lowsmoke fuels were compared in a residential neighborhood to evaluate the extent of air quality improvement by switching household cooking and heating fuels. Comparisons are drawn between the gravimetric results from the two types of filter substrates (Teflon-membrane and quartz-fiber) as well as between the integrated and continuous samplers. It is demonstrated that the quartz-fiber filters reported 5 to 10% greater particulate mass than the Teflon-membrane filters, mainly due to the adsorption of organic gases onto the quartz-fiber filters. Due to heating of sampling stream to 50 C in the TEOMcontinuous sampler and the high volatile content of the samples, approximately 15% of the particulate mass was lost during sampling. The USEPA 24-hr PM2:5 and PM10 National Ambient Air Quality Standards (NAAQS) of 65 g m−3 and 150 g m−3, respectively, were exceeded on several occasions during the 30-day field campaign. Average PM concentrations are highest when D-grade domestic coal was used, and lowest between day 11 and day 20 of the experiment when a majority of the low-smoke fuels were phased in. Source impacts from residential coal combustion are also found to be influenced by changes in meteorology, especially wind velocity. PM2:5 and PM10 mass, elements, water-soluble cations (sodium, potassium, and ammonium), anions (chloride, nitrate, and sulfate), as well as organic and elemental carbon were measured on 15 selected days during the field campaign. PM2:5 constituted more than 85% of PM10 at three Qalabotjha residential sites, and more than 70% of PM10 at the gradient site in the adjacent community of Villiers. Carbonaceous aerosol is by far the most abundant component, accounting for more than half of PM mass at the three Qalabotjha sites, and for more than a third of PM mass at the gradient site. Secondary aerosols such as sulfate, nitrate, and ammonium are also significant, constituting 8 to 12% of PM mass at the three Qalabotjha sites and 15 to 20% at the Villiers gradient site.

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Etyemezian et al.	Atmospheric Environment (2005)	Results from a pilot-scale air quality study in Addis Ababa, Ethiopia	PM_{10}, CO, O_3	Addis Ababa, Ethiopia	PM10 for urban and suburban sites were ~100 and 40 µg m−3 respectively. 34-60% of mass was from geologically derived material (from unpaved roads). Saw daily diurnal peaks associated with traffic, food preperation and heating.	Twenty-one samples were collected during the dry season (26 January–28 February 2004) at 12 sites in and around Addis Ababa, Ethiopia and analyzed for particulate matter with aerodynamic diameter o10 mm (PM10) mass and composition. Teflon-membrane filters were analyzed for PM10 mass and concentrations of 40 elements. Quartz-fiber filters were analyzed for chloride, sulfate, nitrate, and ammonium ions as well as elemental carbon (EC) and organic carbon (OC) content. Measured 24-h PM10 mass concentrations were o100 and 40 mgm 3 at urban and suburban sites, respectively. PM10 lead concentrations were o0.1 mgm 3 for all samples collected, an important finding because the government of Ethiopia had stopped the distribution of leaded gasoline a few months prior to this study. Mass concentrations reconstructed from chemical composition indicated that 34–66% of the PM10 mass was due to geologically derived material, probably owing to the widespread presence of unpaved roads and road shoulders. At urban sites, EC and OC compounds contributed between 31% and 60% of the measured PM10 while at suburban sites carbon compounds contributed between 24% and 26%. Secondary sulfate aerosols were responsible for o10% of the reconstructed mass in urban areas but as much as 15% in suburban sites, where PM10 mass concentrations were lower. Non-volatile particulate nitrate, a lower limit for atmospheric nitrate, constituted o5% and 7% of PM10 at the urban and suburban sites, respectively. At seven of the 12 sites, real-time PM10 mass, real-time carbon monoxide (CO), and instantaneous ozone (O3) concentrations were measured with portable nephelometers, electrochemical analyzers, and indicator test sticks, respectively. Both PM10 and CO concentrations exhibited daily maxima around 7:00 and secondary peaks in the late afternoon and evening, suggesting that those pollutants were emitted during periods associated with motor-vehicle traffic, food preparation, and heating of homes. The morning concentration maxima were likely accentuated by stable atmospheric conditions associated with overnight surface temperature inversions. Ozone concentrations were measured near mid-day on filter sample collection days and were in all cases <45 parts per billion.
Ghose et al.	Environmental Monitoring and Assessment (2005)	Assessment of the status of urban air pollution and its impact on human health in the city of Kolkata.	SPM, RPM, CO, SO_2, NO_X, Pb	Kolkata, India (Calcutta)	RPM concentration varied from 124.1 µg/m3 (at AQ2) to 192.5 µg/m3 (at AQ1) with an overall mean concentration of 152.2 µg/m3, always above national standard of 100. Highest concentrations were typically in the evening. NOx were almost always above national standard of 80 µg/m3. Much of the pollution is likely the result of poor infrastrucure, even for India (only 6% road area- should be 25-30%)	Air pollution has significant effects on exacerbation of asthma, allergy and other respiratory diseases. Like many other magacities in the world the ambient air quality of Kolkata is also being deteriorated day by day. Automobile exhausts and certain industrial pollutants produce O3 by photochemical reactions. The particulate matter, particularly less than 10 µ in size, can pass through the natural protective mechanism of human respiratory system and plays an important role in genesis and augmentation of allergic disorders. Sources of air pollution in the area and the unique problem arising out of the emission from the vehicles, industries, etc. have been described. Ambient air quality was monitored along with micrometeorological data and the results are discussed. The status of air pollution in the area has been evaluated and a questionnaire survey was conducted to estimate the allergic symptoms and exposure to assess the respiratory disorders. The data are analysed to evaluate the critical situation arising out of the emission of air pollutants and the impact on human health due to respirable diseases (RDs) to middle class sub-population (activity-wise) in the area are assessed. A strategic air quality management plan has been proposed. For the mitigation of air pollution problems in the city, the different measures to be adopted to maintain the balance between sustainable development and environmental management have been discussed.
Gupta et al.	Atmospheric Environment (2006)	Trends of particulate matter in four cities in India	PM	Delhi, Mumbai, Kolkata, Chennai - India	PM concentrations are all above national and WHO standards, but are showing decreasing (PM10) and steady (TSP) trends, while population and automobility are greatly increasing. Likely the result of stricter emission standards.	Particulate matter (PM) in all the four Metropolitan cities in India are higher than the prescribed standards of Central Pollution Control Board, India as well as WHO guidelines. Over last 10 years various changes in fuel quality, vehicle technologies, industrial fuel mix and domestic fuel mix have taken place resulting in changes in air quality in these cities. A set of time series analysis methods viz. t-test adjusted for seasonality, Seasonal Kendall test and Intervention analysis have been applied to identify and estimate the trend in PM10 and total suspended particles (TSP) levels monitored for about 10 years at three monitoring sites at each of the four cities in India. These tests have indicated that overall PM10 levels in all four metro cities have been decreasing or stationary. The distinct trends for the monthly averages of PM10 concentrations at Parel, Kalbadevi in Mumbai and Thiruvattiyar in Chennai for the period 1993–2003 were declining by 10%, 6% and 5% per annum, respectively. This is ascribed to a shift in the magnitude and spatial distribution of emissions in the city. However, the monthly averages of TSP do not have a clear trend over the period 1991–2003
Gurjar et al.	Atmospheric Environment (2008)	Evaluation of emissions and air quality in megacities	TSP, CO, SO_2, NO_X,	World megacities	Of 18 megacities considered here 5 classify as having ''fair'' air quality, and 13 as ''poor''. The megacities with the highest MPI, Dhaka, Beijing, Cairo, and Karachi, most urgently need reduction of air pollution. There seems to be a link between a knowledge index (KIR) and air quality.	Several concepts and indicators exist to measure and rank urban areas in terms of their socio-economic, infrastructural, and environment-related parameters. The World Bank regularly publishes the World Development Indicators (WDI), and the United Nations reports the City Development Index (CDI) and also ranks megacities on the basis of their population size. Here, we evaluate and rank megacities in terms of their trace gas and particle emissions and ambient air quality. Besides ranking the megacities according to their surface area and population density, we evaluate them based on carbon monoxide (CO) emissions per capita, per year, and per unit surface area. Further, we rank the megacities according to ambient atmospheric concentrations of criteria pollutants, notably total suspended particles (TSP), sulfur dioxide (SO2), and nitrogen dioxide (NO2). We propose a multi-pollutant index (MPI) considering the combined level of the three criteria pollutants (i.e., TSP, SO2, and NO2) in view of the World Health Organization (WHO) Guidelines for Air Quality. Of 18 megacities considered here 5 classify as having ''fair'' air quality, and 13 as ''poor''. The megacities with the highest MPI, Dhaka, Beijing, Cairo, and Karachi, most urgently need reduction of air pollution.

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Han and Naeher	Environmental International (2006)	A review of traffic-related air pollution exposure assessment studies in the developing world	PM, CO, NO_2, VOC, PAH	Multiple Cities	Airborne pollution is more serious in the developing world than in the developed countries, especially in those developing countries currently under rapid industrialization and changes in land use.	Exposure assessment studies in the developing world are important. Although recent years have seen an increasing number of trafficrelated pollution exposure studies, exposure assessment data on this topic are still limited. Differences among measuring methods and a lack of strict quality control in carrying out exposure assessment make it difficult to generalize and compare findings between studies. In this article, exposure assessment studies carried out in the developing world on several traffic-related air pollutants are reviewed. These pollutants include particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO2), volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs). In addition, it discusses advantages and disadvantages of various monitoring methods (ambient fixed-site monitoring, microenvironment monitoring, and personal exposure assessment using portable samplers) for these pollutants in exposure assessment studies. Also included in this paper is a brief introduction of standards for these pollutants in ambient air or in occupational settings established by the United States Environmental Protection Agency (USEPA), the United States Occupational Safety and Health Administration (OSHA) and the World Health Organization (WHO). The review ends with a summary of the limitations and gaps in recent studies and suggestions for future research in the developing world.
Harrison and Yin	Atmospheric Environment (2000)	Particulate matter in the atmosphere: which particle properties are important for its effects on health?	PM_{10}, $PM_{2.5}$	UK, Portugal, Pakistan	Strong similarities and consistancies in PM composition across the developed world and it matches the emission inventories fairly well. But lots of differences seen from developing countries because of higher pollutant loadings and much more natural wind-blown PM. Despite this, strong similarites in exposure-response from all cities, which is surprising... suggesting, the chemical composition isn't the driver. More work needs to be done to confirm it is particle size (phisical) properties causing effect.	Whilst epidemiological studies have consistently demonstrated adverse effects of particulate matter exposure on human health, the mechanism of effect is currently unclear. One of the major issues is whether the toxicity of the particles resides in some particular fraction of the particles as defined by chemical composition or size. This article reviews selected data on the major and minor component composition of PM2.5 and PM10 particulate matter showing quite major geographic variations in composition which are not reflected in the exposure-response coefficients determined from the epidemiology which show remarkably little spatial variation. The issue of particle size is more difficult to address due to the scarcity of data. Overall, the data presented provides little support for the idea that any single major or trace component of the particulate matter is responsible for the adverse effects. The issue of particle size is currently unclear and more research is warranted.
Health Effects Institute	Special Report (2004)	Health Effects of Outdoor Air Pollution in Developing Countries of Asia: A Literature Review	All	Asia	Urban air pollution contributes each year to approximately 800,000 deaths and 4.6 million lost life-years worldwide (WHO 2002). Two thirds of the deaths and lost life-years occur in the developing countries of Asia. Air pollution in Asian cities is closely tied to levels and trends in economic and social development. As well as rapidly increasing industrialization, urbanization, population growth, and demand for transportation, meteorologic conditions influence air pollution levels in most South and Southeast Asian cities. In western countries, generally indoor air pollution isn't considered for exposure, but in developing countries indoor air pollution can be significantly higher than outdoor.	For pollutant–outcome pairs for which four or more estimates were available, we calculated a summary measure of the percent change in mean number of daily events associated with a 10 µg/m3 increase in the pollutant. PM10, total suspended particles, and the gaseous pollutants SO2 and NO2 were each associated with all-cause mortality. Although the current studies are not representative of the full range of Asian settings, the summary estimates for PM10 and SO2 (an approximately 0.4%–0.5% increase in all-cause mortality for every 10 µg/m3 of exposure) resemble those previously reported by the large US and European multicity studies that used comparable statistical methods (Table 2). Statistical tests for publication bias suggested that this might be an issue for SO2 and all-cause mortality. Correcting for this possible bias resulted in a small reduction in the magnitude of the estimated increase in daily mortality. The size of the Asian air pollution epidemiology literature exceeded our expectations. We identified 138 studies published in the peer-reviewed literature between 1980 and 2003, most published over the past decade. This number may well be an underestimate because we may have failed to identify some papers published only in local peerreviewed literature. Asian investigators may also encounter difficulties in publishing their work in Western journals, so some research may simply go unreported. And although some countries are well represented in the literature, others are not. The majority of studies have been conducted in the more developed countries of East Asia with relatively few studies conducted in South and Southeast Asia, where rapid urban growth has been accompanied by extremely high levels of air pollution.
Kandlikar and Ramachandran	Annual Review of Energy and Environment (2000)	The Causes and Consequences of Particulate Air Pollution in Urban India: A Synthesis of the Science	PM_{10}	Indian Megacities (Delhi, Mumbai)	Indian cities are undergoing a risk transition from 'traditional' risks to 'modern' risks associated with air pollution. The urban poor are bearing the brunt of the risk overlap resulting mostly from the use of biomass as a fuel, while more modern sources (traffic, industry) are experienced similiarly by both the poor and rich. There is a striking imbalance between the knowledge of the issue of urban air pollution and its importance to public health.	Indian megacities are among the most polluted in the world. Air concentrations of a number of air pollutants are much higher than levels recommended by the World Health Organization. In this paper, we focus on Mumbai and Delhi to characterize salient issues in health risks from particulate air (PM10) pollution in Indian cities. We perform a synthesis of the literature for all elements of the causal chain of health risks—sources, exposure, and health effects—and provide estimates of source strengths, exposure levels, and health risks from air pollution in Indian cities. We also analyze the factors that lead to uncertainty in these quantities and provide an overall assessment of the state of scientific knowledge on air pollution in urban India.

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Kaushik et al.	Environmental Monitoring and Assessment (2006)	Assessment of ambient air quality in urban centres of Haryana (India) in relation to different anthropogenic activities and health risks.	TSPM. PM_{10}, SO_2, NO_2	Haryana, India	Particulates exceeded standards for all areas, while NO2 and SO2 were within limits. SO2 increased during winter months with an increase in combustion for space heating and relatively stable atmospheric conditions. Likely corresponds to an increase in hospital visits for acute respiratory diseases during the winter. Monsoon rains also seemed to 'scrub off' concentrations.	Considering the mounting evidences of the effects of air pollution on health, the present study was undertaken to assess the ambient air quality status in the fast growing urban centres of Haryana state, India. The samples were collected for total suspended particulate matter (TSPM), respirable suspended particulate matter (PM10), sulfur dioxide (SO2), and oxides of nitrogen (NO2) during different seasons from 8 districts of Haryana during January, 1999 to September, 2000. The four types of sampling sites with different anthropogenic activities i.e. residential, sensitive, commercial and industrial were identified in each city. The ambient air concentration of TSPM and PM10 observed was well above the prescribed standards at almost all the sites. The average ambient air concentrations of SO2 and NO2 were found below the permissible limits at all the centres. Comparatively higher concentration ofSO2 was observed during winter seasons, which seems to be related with the enhanced combustion of fuel for space heating and relatively stable atmospheric conditions. Air Quality Index (AQI) prepared for these cities shows that residential, sensitive and commercial areas were moderately to severely polluted which is a cause of concern for the residents of these cities. The high levels of TSPM and SO2 especially in winter are of major health concern because of their synergistic action. The data from Hisar city reveals a significant increase in the total number of hospital visits/admissions of the patients with acute respiratory diseases during winter season when the level of air pollutants was high.
Kulkarni and Patil	Environmental Monitoring and Assessment (1999)	Monitoring of daily integrated exposure of outdoor workers to respirable particulate matter in an urban region of India	RPM (PM_5)	Mumbai, India	The average 24-hour integrated exposure to RPM was 322 µg/m3 and exceeded the corresponding PM10 level observed at the nearest Ambient Air Quality Monitoring Station by a factor of 2.25. The daily integrated exposure and therefore the health risk of outdoor workers in an urban area is significantly more serious than that indicated by ambient air quality data. The residential and occupational components of daily exposure were nearly equal (3.62 mgh/m3 and 3.58 mg h/m3, respectively). There was no correlation between person RPM and ambient RPM.	It is more and more recognised that an estimation of the exposure of the population to air pollutants is more relevant than the ambient air quality, since it gives a better indication of health risk. Outdoor workers in an urban region are generally of low income status and are exposed to higher levels of both indoor and outdoor air pollution. Hence respondents from this population subgroup have been selected for this study. Outdoor workers are divided into two categories, viz. traffic constables and casual outdoor workers like watchmen, roadside shopkeepers etc. Most of the respondents are from the lower income group. Each respondent is monitored for a continuous 48-hour period. The sampling frequency is once a week. The study region is situated in the north-west part of the Greater Mumbai Municipal Corporation. It can be classified as industrial cum residential area. The daily integrated exposure of the outdoor workers consists of two major micro-environments, viz. occupational and indoor residential. A personal air sampler was used along with a cyclone to measure levels of Respirable Particulate Matter (RPM). The cyclone has a 50% removal efficiency for particle diameter of 5 m. Paired samples of PM10 (ambient) and RPM (personal) were collected to establish the correlation between them. The average 24-hour integrated exposure to RPM was 322 g/m3 and exceeded the corresponding PM10 level observed at the nearest Ambient Air Quality Monitoring Station by a factor of 2.25. The 90% confidence interval for this exposure is 283–368 g/m3. This study clearly demonstrates that the daily integrated exposure and therefore the health risk of outdoor workers in an urban area is significantly more serious than that indicated by ambient air quality data.
Mage et al.	Atmospheric Environment (1996)	Urban air pollution in megacities of the world	SPM, CO, SO_2, NO_2, Pb, O_3	World megacities (>10 million people)	While the specific air quality issues from each megacity and different, all of those in the developing world have a serious concern about SPM. There is an immediate need for improved monitoring and emissions inventory as a prerequisite for sound management strategies.	Urban air pollution is a major environmental problem in the developing countries of the world. WHO and UNEP created an air pollution monitoring network as part of the Global Environment Monitoring System. This network now covers over 50 cities in 35 developing and developed countries throughout the world. The analyses of the data reported by the network over the past 15-20 yr indicate that the lessons of the prior experiences in the developed countries (U.S.A., U.K.) have not been learned. A study of air pollution in 20 of the 24 megacities of the world (over 10 million people by year 2000) shows that ambient air pollution concentrations are at levels where serious health effects are reported. The expected rise of population in the next century, mainly in the developing countries with a lack of capital for air pollution control, means that there is a great potential that conditions will worsen in many more cities that will reach megacity status. This paper maps the potential for air pollution that cities will experience in the future unless control strategies are developed and implemented during the next several decades.
Nagendra et al.	Transportation Research Part D (2007)	Assessment of air quality near traffic intersections in Bangalore city using air quality indices	SPM, RSPM, CO, SO_2, NO_X	Bangalore, India	At all locations all AQI values developed from data are improving and categorized as 'good' to 'moderate'. Descriptors may be poorly chosen. Ex- Good for PM10 is 0-100 µg m−3 (up to the national standard)	Air quality indices are used for local and regional air quality management in many metro cities of the world. In the present study, air quality indices have been calculated using the US Environmental Protection Agency procedure to assess the status of ambient air quality near busy traffic intersections in Bangalore, India. The measured 24 h average criteria pollutants such as sulfur dioxide, oxides of nitrogen, respirable suspended particulate matter and suspended particulate matter for the period from 1997 to 2005 at three air quality monitoring stations are used for the development of AQIs. The result indicated that the air pollution at all the three air quality monitoring stations can be characterized as 'good' and 'moderate' for SO2 and NOx concentrations for all days from 1997 to 2004. Analysis of air quality indices values for both forms of suspended matter concentrations during 1999–2005 indicates 91% and 94% of the times days are in category 'good' and 'moderate'. The yearly average air quality indices values of respirable suspended particulate matter and suspended particulate matter concentrations indicated decreasing trend and are coming under the category of 'good' and 'moderate' form the category of 'poor' and 'very poor'.

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Padhi and Padhy	Inhalation Toxicology (2008)	Assessment of intra-urban variability in outdoor air quality and its health risks.	SPM, CO, SO_2, NO_2	Suburban India	Residential exposure to highly trafficked roads is associated with respiratory illness. Being within 1 km of a major road had a significant effect of respiratory illness while being within 5km did not.	Ambient air quality along with micrometeorological data was measured in a suburban area of India, from March 2006 to February 2007 in order to assess the intra-urban variability of air pollutants in different parts of the city. The prevalences of asthma and respiratory disorders were determined using a questionnaire survey of 750 adults. The association between intra-urban variability of air pollution and respiratory diseases were evaluated with logistic regression analyses. Compared with subjects staying 5.0 km away from a main road to those subjects living within 0.5 km and 1.0 km had odds ratios of 1.00 (95% CI, 0.85 to 1.50), 3.57 (95% CI, 3.00 to 3.95), and 3.00 (95% CI, 2.85 to 3.50), respectively for doctor-diagnosed asthma. A reduction of measured pollutant concentration with increase in distance from the main road was observed. The study demonstrated that residential exposure to highly trafficked roads is associated with respiratory diseases. Considering the continuing rise in motorized vehicle use and the paramount role of inhalation toxicology, these findings have high public health relevance and should be corroborated in prospective studies.
Shendall and Naeher	Environment International (2002)	A pilot study to assess ground-level ambient air concentrations of fine particles and carbon monoxide in urban Guatemala	$PM_{2.5}$, CO	Guatemala City, Quetzaltenango, Antigua, Guatemala	Street level fine particulates significantly exceed the ambient monitor concentrations. Ground-level PM2.5 concentrations were between 40-90 µg m-3. CO were between 3.5-7 ppm. Both varied by site and city.	Ambient concentrations and the elemental composition of particles less than 2.5 Am in diameter (PM2.5), as well as carbon monoxide (CO) concentrations, were measured at ground-level in three Guatemalan cities in summer 1997: Guatemala City, Quetzaltenango, and Antigua. This pilot study also included quantitative and qualitative characterizations of microenvironment conditions, e.g., local meteorology, reported elsewhere. The nondestructive X-ray fluorescence elemental analysis (XRF) of Teflon filters was conducted. The highest integrated average PM2.5 concentrations in an area (zona) of Guatemala City and Quetzaltenango were 150 Ag m 3 (zona 12) and 120 Ag m 3 (zona 2), respectively. The reported integrated average PM2.5 concentration for Antigua was 5 Ag m 3. The highest observed half-hour and monitoring period average CO concentrations in Guatemala City were 10.9 ppm (zona 8) and 7.2 ppm (zonas 8 and 10), respectively. The average monitoring period CO concentration in Antigua was 2.6 ppm. Lead and bromin experience in the future unless control strategies are developed and implemented during the next several decades.sidential, sensitive and commercial areas were moderately to severely polluted which is a cause of concern for the residents of these cities. The high levels of TSPM and SO2 especially in winter are of major health concern because of their synergistic action. The data from Hisar city reveals a significant increase
Smith et al.	Annual Review of Energy and Environment (1993)	Fuel combustion, air pollution exposure, and health: the situation in developing countries	All	Developing areas	Advantages for LDC: 1- Cheaper to intro clean fuels at the beginning of development rather than to retrofit. 2- Benefit from advances in technology and monitoring from more developed coutries… including exposure modeling. Disadvantages - They are dealing with risk overlap from "new" emission risks as well as "old" risks	As described in the Appendix, there are a number of recent studies of air pollution in developing-country cities (2-5, 1 7 , 99, 100), each of necessity relying heavily on the one available source of comparative international ambient monitoring data, Global Environment Monitoring System (GEMS) (6ab-IO).! In this review , therefore, rather than simply reprqduce the GEMS data, I have chosen to examine developing-country air pollution from the standpoint of a useful analysis technique that has been under development in recent years: "Total Exposure Assessment." Basically the review is composed of four parts: 1 . A brief description of the historical and current relationship between energy use and air pollution. 2. An explanation of the idea of exposure assessment and the power that it can bring to analyses of the health impacts of air pollution. 3. Focusing on developing countries, a global exposure assessment, combining demographic data with GEMS outdoor data and less-developed country (LDC) indoor air-monitoring studies. 4. A review of the health effects literature relevant to the micro-environments found to harbor the largest human exposures .
Smith et al.	Energy (1994)	Air pollution and the energy ladder in asian cities	PM_{10}, CO, NO_2	Pune, India; Beijing, China; Bangkok, Thailand	Improvement for one house alone switching to clean fuel may not be great if no one else nearby joins in, i.e. neighborhood outdoor levels may remain high. It has shown that household fuel choice seems to have the most impact on air pollution exposures at the lowest level of development (Pune), intermediate at middle stages even with use of coal (Beijing), and least in the more economically advanced developing country, where fuel choice seems to have little or no impact (Bangkok). Finally, the results in each city would seem to indicate that true human exposures may be substantially higher than indicated by ambient monitoring stations.	Household fuel switching from lower to higher quality fuels, i.e. movement up the “energy ladder,” generally leads to substantially lower emissions of health-damaging pollutants. The extent to which human exposures are reduced is difficult to predict, however, because of interactions due to penetration of outdoor pollutants into homes and vice versa. In order to help answer the question of how much exposures might be reduced by movement up the energy ladder, a three-city household air pollution study covering particulates (PM10), nitrogen dioxide (NO2), and carbon monoxide (CO) was conducted in and near households spanning the most important current steps in each city's energy ladder. Steps examined were biomass-kerosene-gas in Pune, India; coal-gas in Beijing, China; and charcoal-gas in Bangkok, Thailand. In most instances, 24-hour sampling was conducted and some personal monitoring was undertaken during cooking periods. Preliminary calculations of the exposure and health implications of fuel switching are presented.

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Smith and Ezzati	Annual Review of Environment and Resources (2005)	How environmental health risks change with development: The epidemiologic and environmental risk transitions revisited	General	Developing areas	Risks transition from household to community to global and development proceeds. There is not an increase in chronic diseases with development. All 'disease' decrease with development. Though the proportion of total that are chronic do increase with development. The world illness burden is dominated by category I (infection disease) which is dominated by the developing world and often by children.	Transition frameworks are used to envision the important changes that occur during economic development from poor to middle-income or rich countries. We explain the derivation of and use data from the Global Burden of Disease (GBD) and Comparative Risk Assessment (CRA) projects of the World Health Organization (WHO) to explore the classic epidemiologic transition framework, which describes the changes in causes of illness and death during economic development. We provide the first full empirical test of the environmental risk transition framework, which describes the shift in environmental risks during development from household, community, and global risk factors.We find that the simplistic conclusions commonly drawn about the epidemiologic transition, in particular the increase in chronic diseases with development, are not supported by current data; in contrast, the conceptual framework of the environmental risk transition is broadly supported in a cross-sectional analysis. We also describe important kinds of environmental health risks and diseases that are not well estimated using current methods
Tri-Tugaswati	Environmental Research (1993)	Review of air pollution and health impacts in Indonesia	SPM, SO_2, NO_X, CO, O_X, and NH_3	Indonesia	The air pollution mainly comes from land transportation, industrial emissions, and a densely populated residential area where most people perform their activities. SPM and NOx are the predominant pollutants.	Air quality monitoring is part of the initial strategy in the pollution prevention program in Indonesia. Since 1978, the government of Indonesia has had a commitment to the World Health Organization (WHO) to provide air quality data for the Global Environmental Monitoring System (GEMS Programme)—The WHO/UNEP Project, in which certain cities from all over the world have been selected. Air quality as part of the WHO/UNEP project is monitored with respect to pollutants like SPM, SO2 and NOx. The result of the monitoring indicates that SPM and NOx are the predominant pollutants. Other pollutants such as Ox, H2S, NH3, and CO are also monitored in several big cities in Indonesia. The air pollution mainly comes from land transportation, industrial emissions, and a densely populated residential area where most people perform their activities. Review of the air pollution in Indonesia was based on the reports of the air quality monitoring in several large cities in Indonesia which covered air pollutants such as SPM, SO2, NOx, CO, Ox, and NH3 from 1978 until the latest available data in 1989. This review also discusses health impact investigations conducted in the community, especially from the exposure to SPM, CO, and lead from motor vehicle exhaust.
van Donkelaar et al.	Environmental Health Perspectives (2010)	Global Estimates of Ambient Fine Particulate Matter Concentrations from Satellite-based Aerosol Optical Depth: Development and Application	$PM_{2.5}$	Global	The global population-weighted geometric mean PM2.5 concentration of 20 µg/m3. The WHO interim standard is exceeded over 50% of the population in eastern Asia. Satellite-based monitoring has shown to have good spatial agreement with ground-based monitoring.	**Background:** Epidemiologic and health impact studies of fine particulate matter (PM2.5) are limited by the lack of monitoring data, especially in developing countries. Satelliteobservations offer valuable global information about PM2.5 concentrations. Methods: Global ground-level PM2.5 concentrations were mapped using total column aerosol optical depth (AOD) from the MODIS and MISR satellite instruments and coincident aerosol vertical profiles from the GEOS-Chem global chemical transport model. **Results:** Global estimates of long-term average (2001-2006) PM2.5 concentrations at ~10 km × 10 km resolution indicate a global population-weighted geometric mean PM2.5 concentration of 20 µg/m3. The World Health Organization Air Quality PM2.5 Interim Target-1 (35 µg/m3 annual average) is exceeded over central and eastern Asia for 38% and 50% of the population, respectively. Annual mean PM2.5 concentrations exceed 80 µg/m3 over Eastern China. Evaluation of the satellite-derived estimate with ground-based in-situ measurements indicates significant spatial agreement with North American measurements (r = 0.77, slope = 1.07, n = 1057) and with non-coincident measurements elsewhere (r = 0.83, slope = 0.86, n = 244). The one standard deviation uncertainty in the satellite-derived PM2.5 is 25%, inferred from the AOD retrieval and aerosol vertical profiles errors and sampling. The global population-weighted mean uncertainty is 6.7 µg/m3. **Conclusions:** Satellite-derived total-column AOD, when combined with an aerosol transport model, provides estimates of global long-term average PM2.5 concentrations.
Vichit-Vadakan et al.	Environmental Health Perspectives (2001)	Air pollution and respiratory symptoms: results from three panel studies in Bangkok, Thailand.	PM_{10}, $PM_{2.5}$	Bangkok, Thailand	Associations were found between these pollution metrics and the daily occurrence of both upper and lower respiratory symptoms in each of the panels. The estimated odds ratios are generally consistent with and slightly higher than the findings of previous studies conducted in the United States.	Several studies in North American cities have reported associations between air pollution and respiratory symptoms. Replicating these studies in cities with very different population and weather characteristics is a useful way of addressing uncertainties and strengthening inferences of causality. To this end we examined the responses of three different panels to particulate matter (PM) air pollution in Bangkok, Thailand, a tropical city characterized by a very warm and humid climate. Panels of schoolchildren, nurses, and adults were asked to report daily upper and lower respiratory symptoms for 3 months. Concentrations of daily PM10 (PM with a mass median aerodynamic diameter less than 10 µm) and PM2.5 (airborne particles with aerodynamic diameters less than 2.5 µm) were collected at two sites. Generally, associations were found between these pollution metrics and the daily occurrence of both upper and lower respiratory symptoms in each of the panels. For example, an interquartile increase of 45 µg/m3 in PM10 was associated with about a 50% increase in lower respiratory symptoms in the panel of highly exposed adults, about 30% in the children, and about 15% in the nurses. These estimates were not appreciably altered by changes in the specification of weather variables, stratification by temperature, or inclusion of individual characteristics in the models; however, time trends in the data cause some uncertainty about the magnitude of the effect of PM on respiratory symptoms. These pollutants were also associated with the first day of a symptom episode in both adult panels but not in children. The estimated odds ratios are generally consistent with and slightly higher than the findings of previous studies conducted in the United States. Key words: air pollution, Bangkok, daily diary, particulate matter, respiratory symptoms.